CLAIMS

1. A method of producing precision marks for a metrological scale, employing apparatus including: a scale substrate to be marked at repeated instants by a laser and thereby forming a metrological scale; a laser operable so as to provide light pulses for forming scale markings at the substrate; a displacement device for causing relative displacement between the substrate and the location at which the light is incident on the substrate; and a controller for controlling the relative displacement and the laser,

the method comprising the steps, in any suitable order, of:

operating the displacement mechanism so as to cause relative displacement between the substrate and the light;

using the controller to control the relative displacement and to operate the laser so as to produce light pulses at the substrate;

characterised in that:

the laser produces a plurality of ultra-short output pulses of a fluence at the substrate such that the metrological scale marks are formed by laser ablation.

2. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the substrate is subjected to a bulk temperature rise not exceeding about 6 degrees Celsius at the ablation area as a result of the ablation.

3. A method of producing precision marks for a metrological scale as claimed in claim 1 or 2 wherein

the marks produced contrast optically with unablated substrate.

4. A method of producing precision marks for a metrological scale as claimed in claim 1,2 or 3 wherein the substrate is subjected to a bulk temperature rise causing thermal expansion uncertainties at the substrate ablation area below 3 parts per million.

5. A method of producing precision marks for a metrological scale as claimed in 3 or 4 when appended to claim 3 wherein the optically contrasting marks have an altered reflectivity.

6. A method of producing precision marks for a metrological scale as claimed in claim 5 wherein the reflectivity of the marks is 3 or more times less than the reflectivity of the substrate.

7. A method of producing precision marks for a metrological scale as claimed in any one preceding claim wherein the substrate is flexible.

8. A method of producing precision marks for a metrological scale as claimed in any one preceding claim wherein the substrate is elongate.

9. A method of producing precision marks for a metrological scale as claimed in claim 8 wherein the substrate is a continuous metallic ribbon.

10. A method of producing precision marks for a metrological scale as claimed in any one preceding claim wherein the substrate is of a thickness of less

than about 6 mm.

11. A method of producing precision marks for a metrological scale as claimed in claim 10 wherein the substrate is of a thickness of less than about 1 mm.

12. A method of producing precision marks for a metrological scale as claimed in any one preceding claim wherein the said displacement is continuous.

13. A method of producing precision marks for a metrological scale as claimed in any one preceding claim wherein the fluence at the centre of the incidence is above the threshold for causing ablation by a factor of about 4 to about 12.

14. A method of producing precision marks for a metrological scale as claimed in claim 13 wherein the fluence at the centre of the incidence is above the threshold for causing ablation by a factor of about e^2.

15. A method of producing precision marks for a metrological scale as claimed in any one preceding claim further employing a laser light manipulation device, a displacement sensor for sensing the displacement between the substrate and the location at which the light is incident and a reader for determining the distance between two or more markings at the scale wherein the method further comprises:

issuing a signal from the displacement sensor to the controller;

issuing a signal from the reader to controller;

in response to the signals from the sensor and the reader using the controller to control the manipulation

device, the displacement, and the repeated instants at which the laser ablates the substrate.

16. A method of producing precision marks for a metrological scale as claimed in claim 15 wherein the displacement is linear movement in one direction and the light manipulation device is operable to cause the location at which laser light is incident at the substrate to move transversely to the said direction.

17. A method of producing precision marks for a metrological scale as claimed in claim 15 or 16 wherein the controller is used to further control the manipulation and/or displacement according to known apparatus error information.

18. A method of producing precision marks for a metrological scale as claimed in any one preceding claim wherein the laser light is formed as at least one ellipse where the light is incident the substrate.

19. Apparatus for producing precision marks for a metrological scale comprising: a scale substrate to be marked at repeated instants by a laser and thereby forming a metrological scale; a laser operable so as to provide light pulses for forming scale markings at the substrate; a displacement device for causing relative displacement between the substrate and the location at which the light is incident on the substrate; and a controller for controlling the relative displacement and for operating the laser so as to produce light at the substrate , characterised in that the pulses of light produced by the laser are ultra-short pulses of a fluence at the substrate such that the metrological

scale marks are formed by laser ablation.

20. Apparatus for producing precision marks for a metrological scale as claimed in 19 wherein the substrate is subjected to a bulk temperature rise not exceeding about 6 degrees Celsius at the ablation area as a result of the ablation.

21. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 or 20 wherein the marks produced contrast optically with unablated substrate.

22. Apparatus for producing precision marks for a metrological scale as claimed in claim 19,20 or 21 wherein the substrate is subjected to a bulk temperature rise causing thermal expansion uncertainties at the substrate ablation area below 3 parts per million.

23. Apparatus for producing precision marks for a metrological scale as claimed in 21 or 22 when appended to claim 21 wherein the optically contrasting marks have an altered reflectivity.

24. Apparatus for producing precision marks for a metrological scale as claimed in claim 23 wherein the reflectivity of the marks is 3 or more times less than the reflectivity of the substrate.

25. Apparatus for producing precision marks for a metrological scale as claimed in any one preceding claim 19 to 24 wherein the substrate is flexible.

26. Apparatus for producing precision marks for a metrological scale as claimed in any one preceding claim 19 to 25 wherein the substrate is elongate.

27. Apparatus for producing precision marks for a metrological scale as claimed in claim 26 wherein the substrate is a continuous metallic ribbon.

28. Apparatus for producing precision marks for a metrological scale as claimed in any one preceding claim 19 to 27 wherein the substrate is of a thickness of less than about 6 mm.

29. Apparatus for producing precision marks for a metrological scale as claimed in claim 28 wherein the substrate is of a thickness of less than about 1 mm.

30. Apparatus for producing precision marks for a metrological scale as claimed in any one preceding claim 19 to 29 wherein the said displacement is continuous.

31. Apparatus for producing precision marks for a metrological scale as claimed in any one preceding claim 19 to 30 wherein the fluence at the centre of ablation is above the threshold for causing ablation by a factor of 4 to 12.

32. Apparatus for producing precision marks for a metrological scale as claimed in claim 31 wherein the fluence at the centre of ablation is above the threshold for causing ablation by a factor of e^2

33. Apparatus for producing precision marks for a

metrological scale as claimed in any one of claims 19 to 32 further comprising a laser light manipulation device, a displacement sensor for sensing the displacement between the substrate and the location at which the light is incident and for issuing a signal from the displacement sensor to the controller and a reader for determining the distance between two or more markings at the scale and for issuing a signal from the reader to controller, the controller being further operable in response to the signals from the sensor and the reader so as to control the manipulation device, the displacement, and the repeated instants at which the laser ablates the substrate.

34. Apparatus for producing precision marks for a metrological scale as claimed in claim 33 wherein the displacement is linear movement in one direction and the light manipulation device is operable to cause the location at which laser light is incident at the substrate to move transversely to the said direction.

35. Apparatus for producing precision marks for a metrological scale as claimed in claim 33 or 34 wherein the controller is used to further control the manipulation and/or displacement according to known apparatus error information.

36. Apparatus for producing precision marks for a metrological scale as claimed in any one of claims 19 to 35 wherein the laser light is formed as at least one ellipse at the area where the light is incident at the substrate.

37. A metrological scale comprising a substrate having

scale marks thereat formed by pulses of light from a laser characterised in that the pulses are ultra short ablative pulses.

38. A metrological scale as claimed in claim 37 wherein the scale is one of elongate, planar grid or rotary.

39. A metrological scale as claimed in claim 38 wherein the scale is a continuous metallic ribbon.

40. A metrological scale as claimed in claim 39 wherein the metal is polished stainless steel.

41. A metrological scale as claimed in claim in one of claims 37 to 40 wherein the scale is a of a thickness not exceeding 6 mm.